Pore size effects on physicochemical properties of Fe-Co/K-Al_2O_3 catalysts and their catalytic activity in CO_2 hydrogenation to light olefins

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ABSTRACT

In this work, the hydrogenation of CO_2 to light olefins has been studied over the Fe-Co/K-Al_2O_3 catalysts, while focusing on the impact by the pore sizes of Al_2O_3 supports including 6.2 nm (S-Al_2O_3), 49.7 nm (M-Al_2O_3) and 152.3 nm (L-Al_2O_3) on the structure and catalytic performance. The characterization results demonstrate that the pore sizes of the Al_2O_3 supports play a vital role on the crystallite size of Fe_2O_3, the reducibility of Fe_2O_3 and the adsorption-desorption of CO_2 and H_2. The catalyst with the smallest pore size (CS-Al_2O_3) allows the formation of a small Fe_2O_3 crystallite size due to pore confinement effects, yielding a low active component (Fe) after reduction at 400 °C for 5 h. The catalysts with the larger pore sizes of 49.7 nm (CM-Al_2O_3) and 152.3 nm (CL-Al_2O_3) provide the larger Fe_2O_3 crystallite sizes which require a longer reduction time for enhancing degree of reduction, resulting in a high metallic Fe content, leading to a high CO_2 conversion and a high selectivity toward hydrocarbon. Eliminating diffusion limitation by increasing the pore sizes of Al_2O_3 supports can suppress the hydrogenation of olefins to paraffins and thus the largest pore catalyst (CL-Al_2O_3) gives the highest olefins to paraffins ratio of 6.82. Nevertheless, the CL-Al_2O_3 also favors the formation of C_{5+} hydrocarbon. Therefore, the highest light olefins yield (14.38%) is achieved over the catalyst with appropriated pore size (CM-Al_2O_3).

KEYWORDS

Light olefins; CO_2 hydrogenation; Fe-based catalysts; Al_2O_3; Pore sizes

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